

TCI:
TRAFFIC SIGNAL CONTROLLER INTERFACE
VERSION 1.0

USER'S MANUAL
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NATIONAL INSTITUTE FOR ADVANCED TRANSPORTATION TECHNOLOGY
UNIVERSITY OF IDAHO

Zaher Khatib
Assistant Professor
Civil Engineering Department
University of Idaho

TCI: Traffic Controller Interface

Version 1.0

Traffic Signal Optimization Conversion
And Coordination Utility

By

Zaher Khatib, Ph.D., P.E., P.T.O.E.
Civil Engineering Department
University of Idaho
Moscow, ID 83844-1022
(208) 885-2957
Fax (208) 885-2877
Email zkhatib@uidaho.edu

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TCI v1.0

Software release notes.

August 18, 1999

Zaher Khatib
University of Idaho

TCI was created as a link between popular signal optimization software and signal controller interface software. After performing signal optimization with the Arterial Analysis Package (AAP), using either PASSER II-90 or TRANSYT-7F, TCI effectively translates optimized signal timings into the format of interface software for TCT traffic signal controllers or other NEMA controllers.

The included diskette contains the Visual Basic application and several files for demonstration use without the Arterial Analysis Package. The diskette contains these files:

TCI.exe	<i>-the Visual Basic application</i>
Twenty.ain	<i>-AAP input file for twenty intersection arterial</i>
Twenty.gdn	<i>-AAP2NEMA output file for twenty intersection arterial</i>
Six.ain	<i>-AAP input file for six intersection arterial</i>
Six.gdn	<i>-AAP2NEMA output file for six intersection arterial</i>
Three.ain	<i>-AAP input file for three intersection arterial</i>
Three.gdn	<i>-AAP2NEMA output file for three intersection arterial</i>

The files with .gdn or .ain extensions are the files generated by AAP when optimization is performed according to directions of AAP software. Included files can be read by TCI but cannot be pulled directly into AAP. They are merely included to allow trial of the TCI application. If AAP and AAP2NEMA are installed on a system, TCI can be used to translate any file group from AAP that has been optimized with PASSER II-90 or TRANSYT-7F and translated from single ring sequential to dual ring concurrent with AAP2NEMA. An example of this process is included within this document.

TCI v1.0

User's Manual

Background

Timings for traffic signal controllers are typically entered through keypads or with the aid of software interface applications. A trained technician who must travel to the location of the controller in the field and reprogram with timings designed by an engineer can accomplish manual keypad entry. Deploying a technician for each change can be quite inefficient; especially for minor adjustments to phase timings. Software interface programs between controllers and desktop PC's allow easier entry of signal design data into controllers by one or two methods. Most simply, interface software enables a PC serial connection to the controller in the field and allows data transfer on site. The second method is to make the serial connection with modems so engineers and technicians can dial into controllers and change timings from remote locations such as a traffic control center. Interface programs are normally designed for user-friendly data exchange and programming of complete controller functions including phases timings.

During signal timing design, many engineers use optimization tools such as PASSER II-90 (PII-90) and TRANSYT-7F (T7F). These applications accept intersection approach data such as volume, speed, and geometry to create an optional signal-timing plan that will minimize disutility or maximize progression as defined by the optimization software. Output formats of these software applications make it less practical for traffic engineers to use.

Once optimization is accomplished, the software (PII-90 or T7F) generates output in single ring sequential format. The Idaho Transportation Department (ITD) and other state agencies within the United States, use controllers that follow the National Electronics Manufacturers Association (NEMA) dual ring concurrent standard. Before useful for controllers in Idaho and other states, single ring sequential timing plans must be translated into dual ring concurrent timing plans.

In addition to entering movement timing data, it is often necessary to enter coordination timing data. Coordination timing refers to a signal controller's capability for time synchronization with other controllers on an arterial or sequence of intersections along a route. Controller time sync is accomplished with offset times based upon vehicle approach velocities between intersections. AAP can calculate an optimized offset time for each intersection along an arterial, but it isn't designed to calculate more advanced overlapping time periods necessary for side street demand actuation.

Side street demand actuation is appropriately termed semi-actuation because main street approaches in a coordinated system do not function according to demand. In contrast, a fully actuated intersection is one that is operating independently of other intersections and all approaches are functioning according to vehicle demand. For coordination to work on an arterial with more than one semi-actuated intersection, controllers at all the

intersections must be programmed to end side street actuation and give priority to the main street through movements. During a signal cycle, the end of side street actuation is called a Force Off. Leading up to a Force Off time is an interval of time when side street demand can be served without causing an advancing platoon of vehicles on the main street to stop. This interval is called a Permissive Period. Neither TRANSYT 7-F nor PASSER II-90, by themselves or through AAP are capable of computing these coordination parameters. TCI however, is designed to calculate the Force Off Times and Permissive Periods for all significant minor movements at each intersection within an arterial.

Purpose of Manual

The purpose of this application manual along with software AAP, AAP2NEMA, and TCI is to provide users with tools to optimize traffic signal timings for individual intersections or intersections along an arterial. TCI aids in the process of timing design entry into signal controllers for implementation. Sections in this manual will address specific areas of developed software necessary for TCI functions and, where appropriate, will refer user to respective application manuals.

Installation

Since TCI was designed to work with the AAP (Arterial Analysis Package), it is essential to install AAP on the same computer. AAP is available through:

McTrans Center
University of Florida
512 Weil Hall
P.O. Box 116585
Gainesville, FL 32611-6585
(352) 392-0378

OR

PC-TRANS
Kansas University Transportation Center
2011 Learned Hall
Lawrence, KS 66045
(785) 864-5655

The AAP operates as a front end to (1) PASSER II-90, (2) TRANSYT-7F, and (3) AAP2NEMA. Software packages (1, 2, and 3) must also be obtained from either McTrans or PCTTRANS and installed according to instructions given in the AAP manual.

If defaults for installation are followed, the paths to each application will be as follows:

C:\AAP

C:\AAP\PASSER

C:\AAP\TRANSYT

One should verify the following directories or folders are all present after installation of AAP, PASSER II-90, and TRANSYT-7F:

C:\AAP\MAINDATA

C:\AAP\MAINDATA\DATA

C:\AAP\MAINDATA\EXAMPLE

C:\AAP\MAINDATA\TMC

C:\AAP\TRANSYT\MAINDATA

C:\AAP\TRANSYT\EXAMPLE

AAP2NEMA is installed directly into C:\AAP folder and is executed from a pull down menu in AAP. Refer to installation instructions included with AAP2NEMA.

TCI can be installed by double-clicking setup.exe on the setup CD and following the on-screen instructions. TCI can be installed into any folder, however, it defaults to "c:\program files\TCI v1.0".

TCI should only be used after a successful run of AAP2NEMA. This also means a successful run of either PASSER II-90 or TRANSYT-7F from within AAP. A successful run will generate files used by TCI. Generated files contain cloned input data as well as optimized signal timings. If defaults are followed during installation of optimization software for AAP, the path to the files are C:\AAP\MAINDATA\EXAMPLE and bear the name of the file group established for the project in AAP. If the project filename is "Sample", then the necessary files generated by AAP are:

Sample.AAP
Sample.AIN
Sample.GDN
Sample.PIN
Sample.TIN
Sample.AOF
Sample.POF
Sample.TOF
Sample.GDF

Explanations of these files are included in section 3-19 of the AAP User's Guide. Although critical to TCI, the .GDN file isn't explained in the AAP User's Guide. Files with the .GDN extension are generated by AAP2NEMA and contain the optimized signal timing parameters in NEMA format. TCI reads AAP output files and arranges the data into the format of Controller Software. It effectively enhances the usefulness of optimization tools and interface software. Two modules also aid in the design of pedestrian timings and coordination parameters.

TCI Operation

TCI is be opened by clicking the “Start” button, selecting “Program Files”, and clicking on the TCI v1.0 Icon. Notice that TCI v1.0 is not contained in a sub folder to “Program Files”.

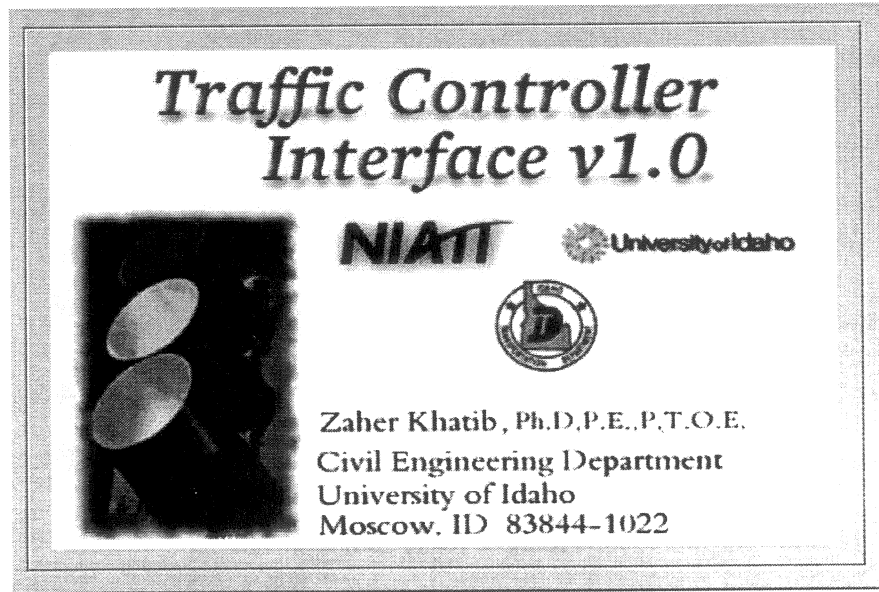


Figure 1. Splash Screen

Start Up

This initial screen is the initial screen that displays when TCI is loaded. TCI contains five major sections: Global Settings, Signal Timings, Pedestrian Timing, Coordination, and Manual Entry. When TCI is first loaded the Global Settings screen is displayed. At this time, you can set the global values or proceed to open, import, or manually enter the signal timings.

The Pedestrian section contains tools to calculate Pedestrian timings given intersection approach geometry. It also can give timings for certain types of pedestrian stage crossings. The Coordination section contains tools for computing Force Off times and Permissive Periods for semi-actuated/coordinated signal control. Manual Entry is an environment for keying in data that would otherwise come from signal optimization software.

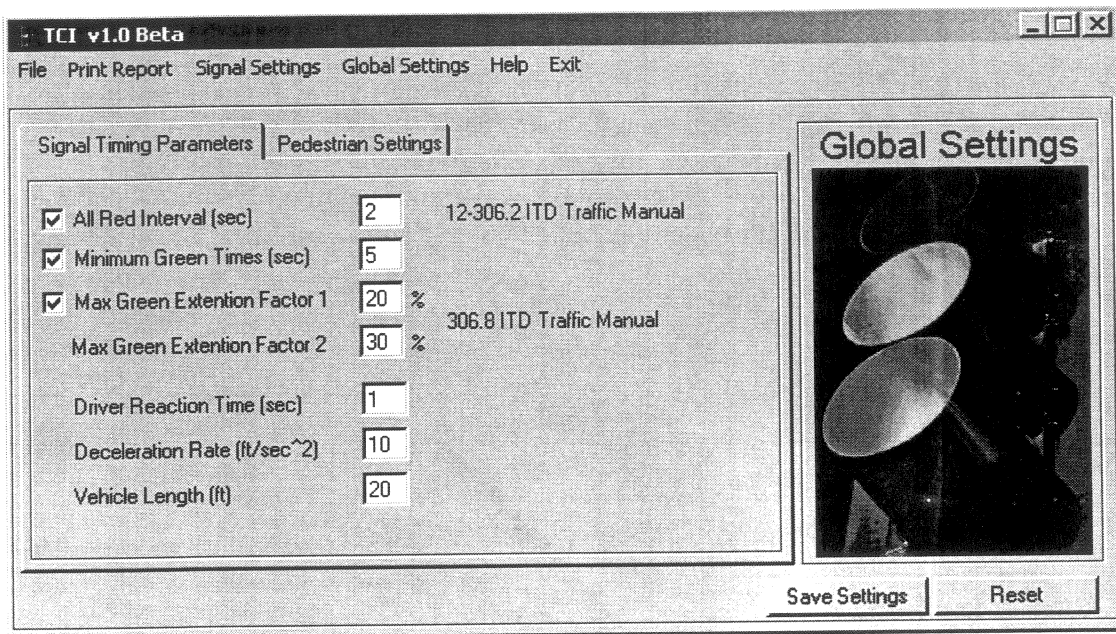


Figure 2. First View

Loading the Signal Data

In the uppermost left corner of the client window is a file menu option called “File” used to specify if signal data will come from an AAP file, Manual Entry, or a native TCI file. After successful optimization in AAP and conversion using AAP2NEMA, the user will click Import.

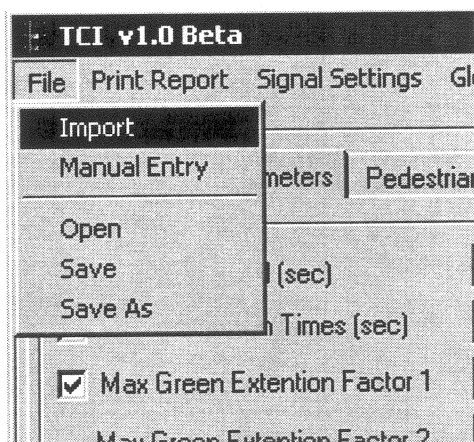


Figure 3. Menu Item - Import

The user will be presented with a standard Windows™ “file open” dialog box where they select an AAP output file ending in either .gdn or .ain.

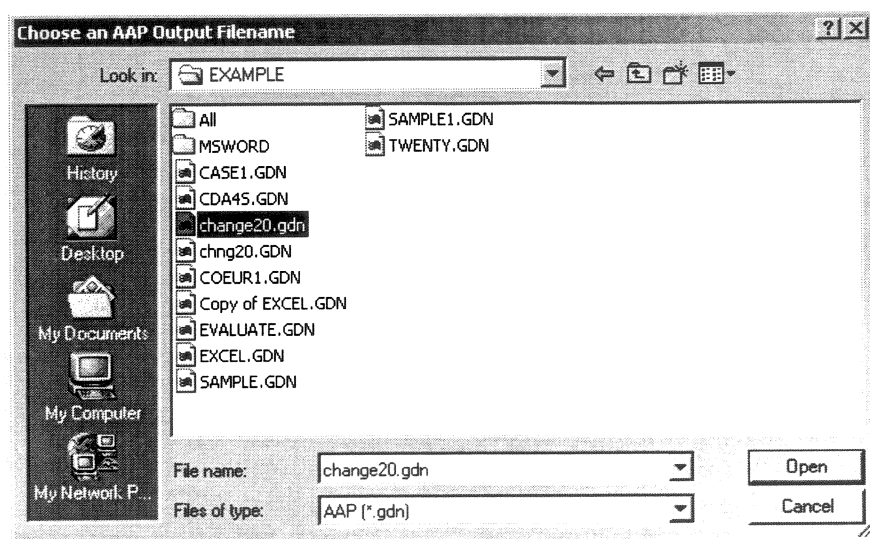


Figure 4. File Group Input

Manual Entry Wizard

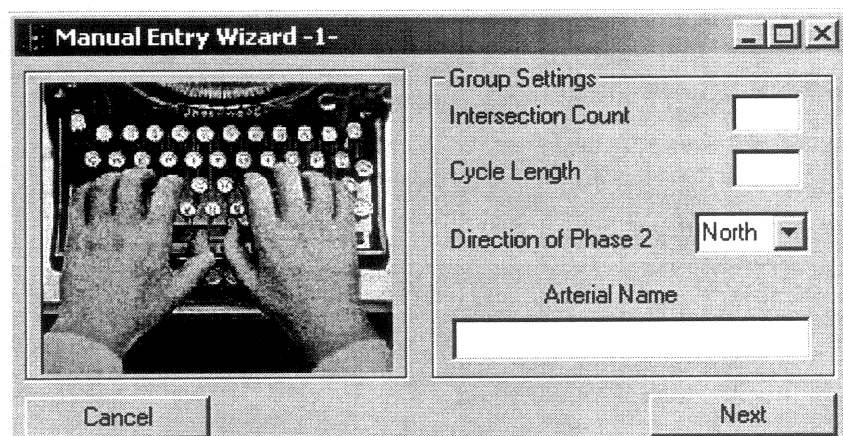


Figure 5. Manual Entry Wizard Part 1

Figure 5 displays the opening screen for the Manual Entry Wizard. The first screen of the wizard requires the user to input the Number of Intersections, Cycle Length, Direction of Phase 2, and the Arterial Name. If desired, the user may edit the data currently loaded in TCI by “un-checking” the “New” checkbox. The checkbox does not appear if data is not currently loaded into TCI.

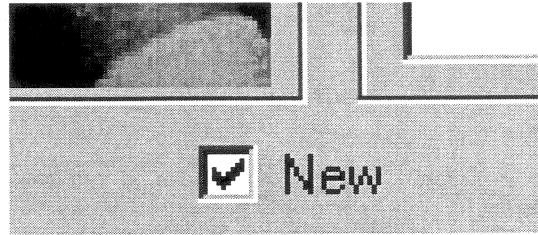


Figure 6. Manual Entry Wizard – New Checkbox

If the values are invalid or left blank and error message is displayed. **WARNING:** *After the user clicks the “Next” button the currently loaded data will be erased or modified.* The follow screen allows the user to modify for insert data pertaining to each intersection. It is required the following data to be entered for each intersection: Cross street name, Offset, Sequence, directions for phase #1 through phase #8, time allocated to each phase, and approach velocities in miles per hour. Phase data can, however, be left blank if the user leaves the all data pertaining to that phase blank.

The screenshot shows the 'Manual Entry -2-' window with the following fields:

- Intersection: 1**
 - Name: First
 - Arterial: L (dropdown)
 - Sequence: T (dropdown)
 - Cross Street: L (dropdown)
 - Offset: 0
- Phase Movement**

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
NBL (dropdown)	SBT (dropdown)	EBL (dropdown)	WBT (dropdown)	SBL (dropdown)	NBT (dropdown)	WBL (dropdown)	EBT (dropdown)
- Allocated Green Times (seconds)**

15	45	15	15	15	45	15	15
----	----	----	----	----	----	----	----
- Approach Speeds**

45	40	30	30	40	45	30	30
----	----	----	----	----	----	----	----
- Navigation:** Back (button), Next (button)

Figure 7. Manual Entry Wizard Part 2

Internal checking hasn't been created for the manual entry part of the program. As a result, the program will take anything entered and grind it into the calculations throughout the entire application. Care should be taken to obtain realistic signal design parameters before entering them into the manual entry fields. Following dual ring signal design rules and one format rule will result in successful use of AAP bypass with the Manual Entry option.

There are only two rules to follow for data entry. 1) Assign phase directions according to dual ring compatibility. Even though some newer controllers allow input for 12 phases, TCI is limited to these 8 phases: NBL, SBT, EBL, WBT, SBL, NBT, WBL, and EBT. They can be in any order as long as the dual ring compatibility rules are followed. For example, phases 1 and 2 must be mutually incompatible, but compatible with phases 5

and 6. **WARNING:** *TCI does not current check for dual ring compatibility.* This feature will be incorporated into future versions of TCI.

To keep combination possibilities small, it has been assumed that the main street in an arterial is either northbound or southbound. Coordinated phases will therefore be 2 and 6 or 1 and 5, depending on the assignment given in AAP or Manual Entry. TCI will handle other combinations, but the coordination results will have to be interpreted.

After all data for an intersection is entered, the user will click on the “Next” button until all intersection data is entered. The user may use the “Back” button or the scroll bar to return or advance to any intersection. Finally the user is then presented with finish dialog box, which will return the user to the Main TCI screen.

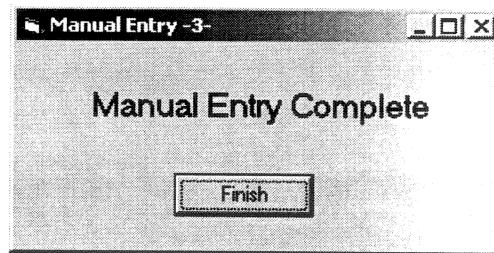


Figure 8. Manual Entry Complete Part 3

Global Settings

The Global Settings section contains global defaults and settings for Signal and Pedestrian Timings sections. Any changes made to the Global Settings will automatically update the Timings sections data if present. The Global Settings section also contains two buttons, “Save Settings”, and “Reset”. The “Save Settings” button saves the current global settings into the system registry. This causes future sessions of TCI to use the new user saved “Global Settings” as the defaults. The “Reset” button simply resets the Global Settings to the original TCI defaults.

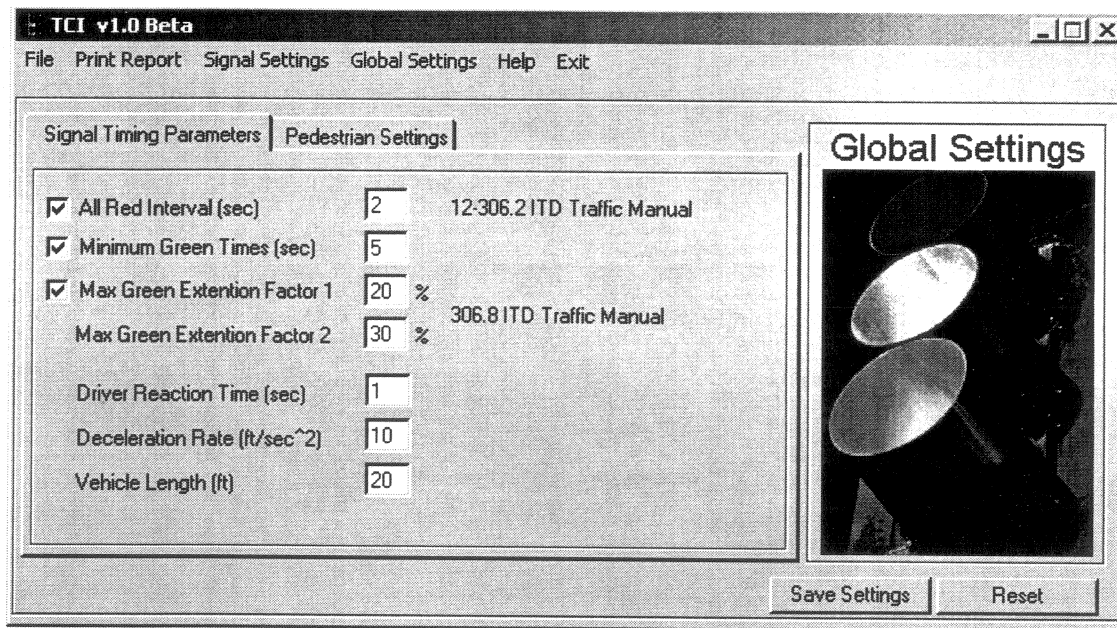


Figure 9. Global Settings

Signal Timing Parameters

All Red Interval

If the All Red Interval is checked then the global All Red value will be used. If it is unselected then the All Red Interval is calculated based on the Approach Grades, Driver Perception/Reaction Times, Vehicle Lengths, and the Width of the intersection. Driver Reaction Time, Deceleration Rate, and the Vehicle Length values are found in the Global Settings section. The default value throughout Idaho is 2 seconds according to section 12-306.2 in the ITD Traffic Manual.

The All Red interval is so called because each movement of each approach at an intersection is displaying a stop signal. This is a safety measure that helps clear all traffic from a previous movement before another conflicting movement is permitted to enter the intersection.

Minimum Green Time

Normally, minimum green times for traffic movements are determined using geometric data. It is the time it would take a pedestrian to enter the crosswalk and walk to the middle of the farthest lane. Sometimes, for purposes of coordination, it is necessary to allow the coordination parameters to control the minimum green times.

Checking the minimum green times will set the minimum green times according to the pedestrian clearance intervals. Un-checking will use the global value. It is recommend to use low enough value to allow permissive periods to control the minimum green times.

Maximum Green Time

Coordination can also influence values for maximum green times. It is necessary to choose how the maximum green times will be handled. Un-checking the maximum green time will assign the maximum green time of 127 seconds to each phase so that the coordination Force Off Times will control the max green time. Checking the maximum green time will use the global Maximum Green Extension Factors.

ITD Traffic Manual section 12-306.8 describes the maximum green time as the necessary extension of green to accommodate a 20 or 30 percent increase in average queue length. Since green times given by the optimization software are minimum times to serve the average queues, they can be increased by the same factor of queue increase. Some controllers can utilize a second max green time; thus, the needs for a second max green extension factor. Maximum green times only apply to intersections with semi or fully actuated control. Fixed time signals do not use this feature.

Pedestrian Settings

Pedestrian Settings are default settings used in the Pedestrian Timings section.

Signal Timing Parameters		Pedestrian Settings	
Pedestrian Curb Leave Time (WALK sec)	5		12-306.4 ITD Traffic Manual
Pedestrian Walk Speed (ft/sec)	4		
Default Average Lane Width (ft)	12		
Default Number of Lanes	1		
Default Grade (%)	0		

Figure 10. Pedestrian Settings

Pedestrian Timing

TCI will help calculate timings for normal pedestrian phases that move with through vehicle phases. TCI calculates pedestrian timings based upon geometric data.

TCI v1.0 Beta -- C:\Aap\MAINDATA\EXAMPLE\change20.gdn

File Print Report Signal Settings Global Settings Help Exit

Intersection 1 Intersection Name: First Sequence: LT LT Phase 2: South Cycle Length: 90 Arterial Name: University

Signal Timings Pedestrian Timing Coordination

5 Pedestrian Curb Leave Time 4 Pedestrian Walk Speed (ft/sec) 12-306.4 ITD Traffic Manual

☐ Use Stage Crossing

	Approach Lane Count	Departure Lane Count	Average Lane Width	Grade (%)	Curb Leave Time	Pedestrian Clearance
EB	1	1	12	0	5	4.5
NB	1	1	12	0	5	4.5
WB	1	1	12	0	5	4.5
SB	1	1	12	0	5	4.5

Figure 11. Pedestrian Timing

Walk Time

Step 1 is to select time for Pedestrians to leave curb and enter crosswalk. According to ITD Traffic Manual section 12-306.4, the MUTCD recommends using 4-7 seconds.

For intersections in Idaho, a 5 second walk time is normally sufficient. Where higher volumes of pedestrians are present, a longer walk time may be needed to allow queues to leave curb. If a shorter or longer walk time is needed, the user will click with the mouse on the down arrow in the green box and select desired time in seconds.

Pedestrian Clearance

Step 2 is to select a pedestrian walk speed. This will be used to determine the time needed for pedestrians to walk from the curb to the center of the farthest lane of conflicting approach. The default value is 4 feet per second, but the user can select faster or slower walking speeds by clicking on the down arrow in the yellow box and choosing an appropriate value.

Although geometric data is entered into AAP to calculate saturation flow parameters, it isn't found in the output files. Therefore, step 3 is to calculate pedestrian timings by entering geometric data for each intersection. If approaches on the main street are directionally separated by raised medians or some kind of island, stage crossing may be employed for pedestrians. Checking the small box " Use Stage Crossing", TCI will automatically calculate the pedestrian times required for each stage. The user has to input the proper geometric data for each intersection.

Yellow Change Interval

Yellow intervals for each intersection are based on approach speeds. Approach speeds are entered into AAP and echoed with the optimized output. Speeds are extracted and compared to a table from section 12-306.2 in the Idaho Transportation Department Traffic Manual. ITD standard yellow intervals are included in table 1 on the following page.

Table 1. Standard Yellow Intervals

Approach Speed	Standard Yellow Interval
25 mph	3.2 sec
30 mph	3.2 sec
35 mph	3.2 sec
40 mph	4.0 sec
45 mph	4.0 sec
50 mph	4.0 sec
55 mph	4.0 sec
>55 mph	5.0 sec

Coordination Parameters

TCI can calculate the Force Off Times and Permissive Periods for each non-coordinated movement at all arterial intersections.

As mentioned earlier, Force Off Times and Permissive Periods are required for coordinated-actuated signal control. A call for service on a side street must be served with minimum green before an approaching platoon of vehicles on the main street arrives. The Permissive Period is the interval when a non-coordinated side street demand call can be acknowledged. The Force-Off Time is when a particular movement must be terminated, whether it is being served from a demand call or part of the sequence of a cycle.

Force Offs	Time From Yield Pt.	Permissive Period	Start	End
1	45	1	30.8	34.8
2		2		
3	15.8	3	0	4.8
4	30.8	4	15.8	20.6
5	45	5	30.8	34.8
6		6		
7	15.8	7	0	4.8
8	30.8	8	15.8	20.6

Figure 12. Coordination

The method used to compute these parameters follows the TRAF/NETSIM method. The basic pattern for Force Off Times and Permissive Periods are given here for a signal design where movements 3 and 7 follow 2 and 6, the coordinated movements.

Force off time for $\Phi 3/7 = \Phi 2/6$ clearance + $\Phi 3/7$ split - $\Phi 3/7$ clearance

Duration of Permissive Period 1 = Force Off $\Phi 3/7$ - $\Phi 3/7$ min. green - $\Phi 2/6$ clearance

There are three permissive periods in a normal NEMA signal design. The first begins at the end of the coordinated movement.

Working with AAP and AAP2NEMA

This section will highlight important steps in the process of AAP execution, conversion into NEMA timing parameters with AAP2NEMA, and translation into controller format with TCI. For more detailed instruction, see AAP manual.

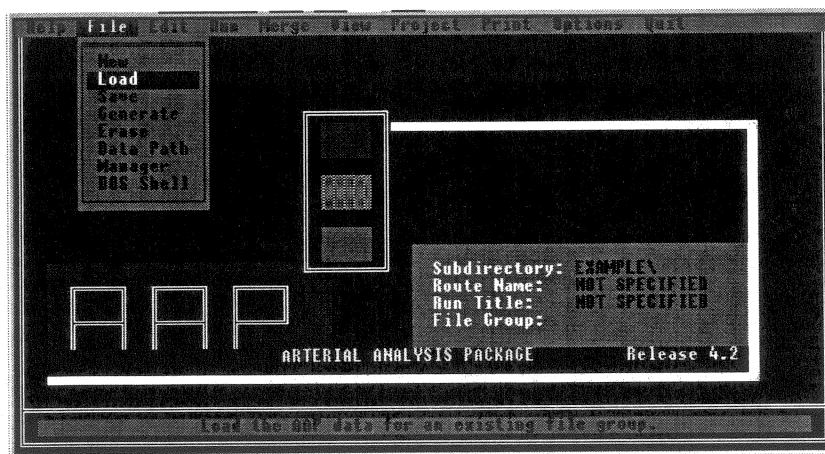


Figure 13. AAP Initial Screen

AAP

Installation of AAP will create a sample file group called "Sample". This file group will be referred to many times in this section to illustrate common points in every run of AAP. When opened into AAP, the file group Sample contains arterial data with 4 intersections.

This can be verified by executing AAP, loading Sample, and browsing through the submenu items within the "Edit" pull down menu. To load the Sample file group, choose File → Load, then choose Sample and click on <OK>. The artery is called 123456789012345 and the intersecting streets are FIRST ST, SECOND ST, THIRD ST, and FOURTH ST. Phase 2 is north bound and is the forward arterial direction. All approaches on all intersections have four lanes; 2 through, 1 left and 1 right. All through lanes are 12 feet wide, while right and left lanes are 11 feet wide. Arterial approach speeds are 35 mph and cross street approach speeds are 30 mph. Other necessary data has been entered into the Edit → Artery Setup, Artery Data, Approach Data, Timing Plan, Run Instructions, Progression Data, and Optional Data screens.

Note: AAP allows the user to assign a forward arterial direction as N, S, E, or W. TCI can arrange the resulting optimized timings with proper assignments to corresponding movements; however, calculating Force Off Times and Permissive Periods will require user interpretation for clear meaning. For consistency in all calculation steps of TCI, it is recommended to assign the coordinated movements to the left side of the dual ring diagram, or strictly follow the dual ring movement assignments attributed to NEMA or the assignments used in Idaho.

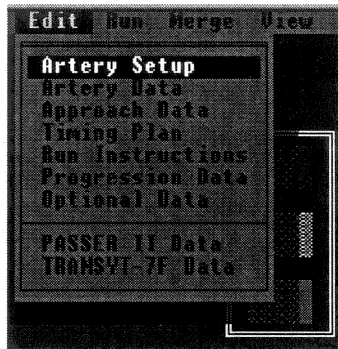


Figure 14. AAP Edit Menu

For assistance with AAP input screens please refer to the AAP user's manual or the online help accessible by pressing F1 or F3 key.

Running PASSER II-90 or TRANSYT-7F from AAP

Selecting "Run" in AAP will open up a menu with PASSER II-90 and TRANSYT-7F. The user can select either optimization routine. If all the artery setup data is correct, the preprocessor will run chosen optimization application. The output can be viewed by selecting an option from the "View" menu.

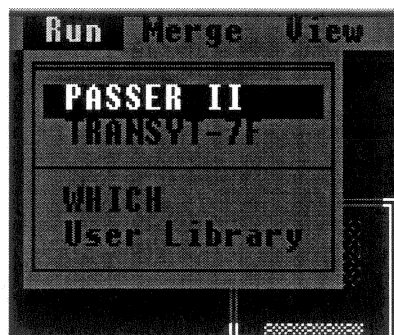


Figure 15. AAP Run Menu for PASSER II-90 or TRANSYT 7F

AAP2NEMA

Although output can be viewed from AAP, timing plans are in single ring sequential format and therefore must be converted to dual ring concurrent before useful in Idaho controllers. Selecting View→Timing Plan, as shown in Figure 16, opens AAP2NEMA conversion utility. Selecting File→Load opens up file group folder with files that have

the same group name, but different extensions. If the last optimization run in AAP was with PASSER II-90, the user will select to load [file group name].GDP; otherwise, if TRANSYT-7F was used, [file group name].GDT will be chosen. A window with choice of (L)oad design values into current data, (F)ind next run, and (A)bort operation will appear. Pressing the "I" key chooses to load data, after which the program has created the [file group name].GDN file and the timing plan has been converted into NEMA format.

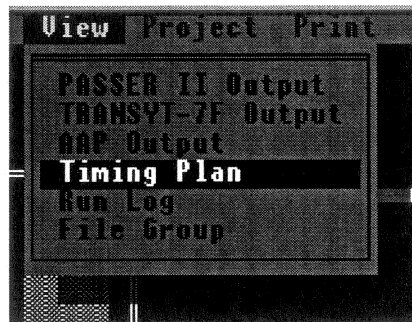


Figure 16. AAP View Menu to Open AAP2NEMA

It can be verified by going to Edit→Timing Plan. This window shows how the timing plan has been converted.

When finished with AAP2NEMA, select Exit→Quit. This will bring up a prompt to save [file group name]. Saving is normally a good idea and doesn't usually affect anything that has been done so far.

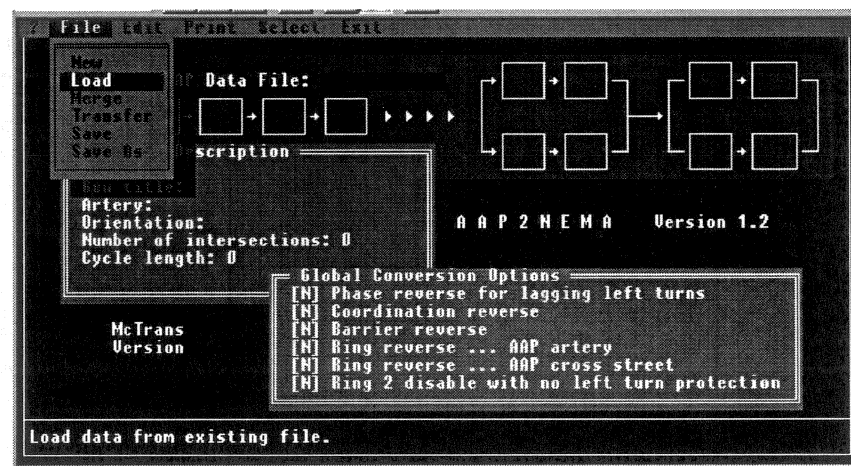


Figure 17. AAP2NEMA Conversion Utility

Upon exiting AAP2NEMA, the AAP main menu screen appears. If everything ran O.K. and the timing parameters seemed reasonable, AAP can be exited by selecting Quit. Again, an option to save before exiting is brought up. If the file group has been worked on before, selecting to save will bring up an option to replace the old file.

TCI Example

In terms of TCI, after timing parameters are satisfactorily obtained and converted, AAP and AAP2NEMA aren't required. From this point, it is assumed that Sample was opened, optimized by running PASSER II-90 or TRANSYT-7F, and converted with AAP2NEMA. One way to verify that this has occurred is to check the C:\AAP\Maindata\Example\ folder. Look for Sample.GDT or Sample.GDP indicating that T7F or PII-90 has been run. Also, make sure that Sample.AIN and Sample.GDN are present. Running T7F or PII-90 generates Sample.AIN and, running AAP2NEMA produces Sample.GDN.

Begin by loading TCI as a client, then follow the steps as shown above.

Software Support

McTrans and PCTTRANS provide support for software they distribute. During development of TCI, common problems occurred with AAP that McTrans was able to help resolve. Mostly, the problems were related to arterial coding errors.

McTrans and PCTTRANS cannot support traffic signal controller software. Interface software for any controller is proprietary and not subject to research and development by outside agencies. Electronic software links to controller cannot be made. Printing the TCI output is intended to help engineers and technicians at ITD narrow the gap between useful optimization tools and proprietary software used to program controllers. Version 1.0 of TCI is an intended to determine how effective a "bridge" can be.

Questions and problems with TCI should be directed to Dr. Zaher Khatib at the University of Idaho. Questions are anticipated and feedback from practitioners at ITD is anxiously expected so improvements can be made. Please contact us for help or to discuss enhancements.

Zaher Khatib, Ph.D., P.E., P.T.O.E.
Assistant Professor
Civil Engineering Department
University of Idaho
Moscow, ID 83844-1022
Voice: 208-885-2957
Fax: 208-885-2877
zkhatib@uidaho.edu